

2555 - SHAPE ENGINEERING.

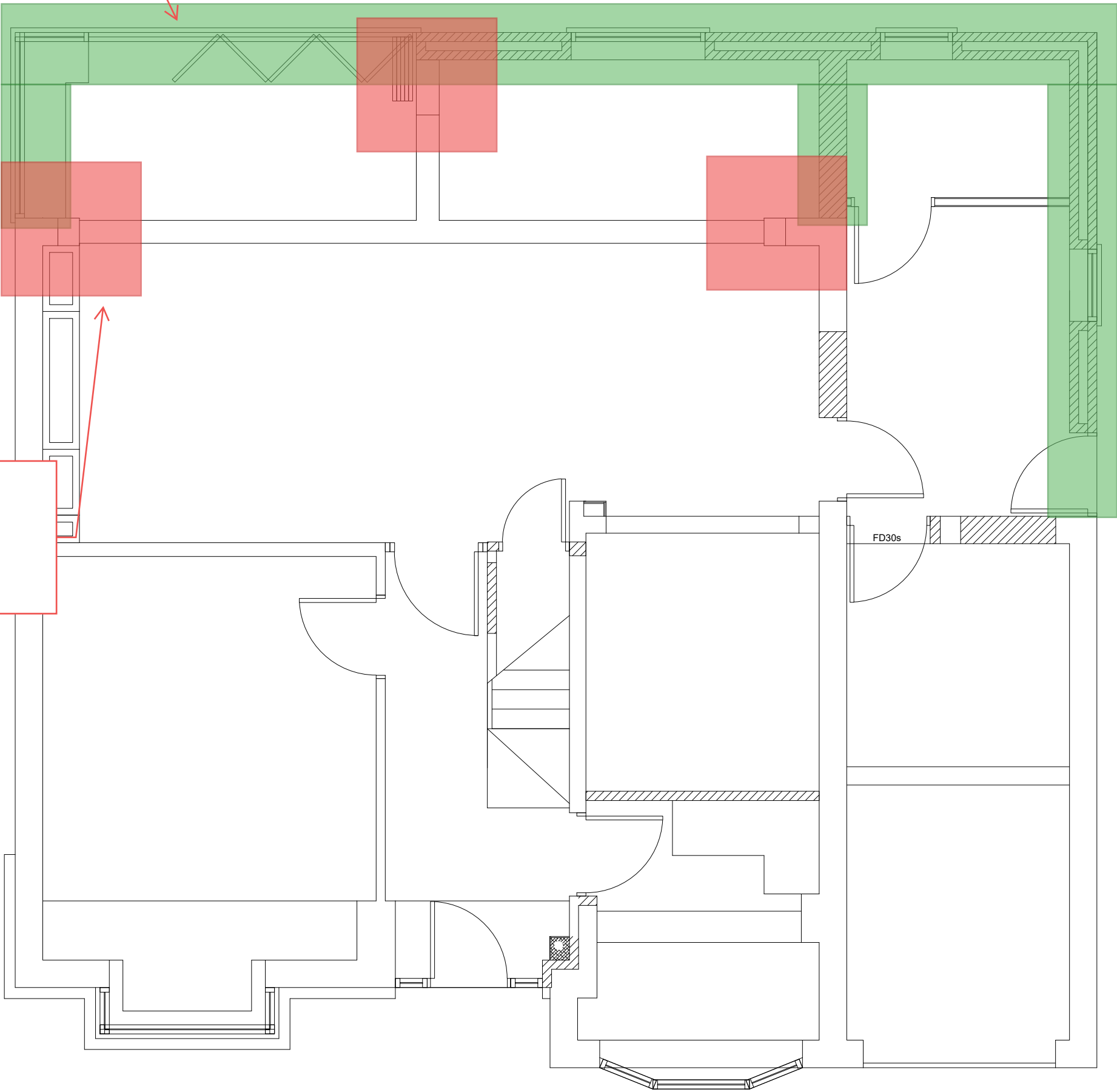
10 LLOYD ROAD, PRESCOT, KNOWSLEY
L34 6LG

NEW ROOF TIMBER TRUSSES TO
BE DESIGNED BY SPECIALIST.

ALL PADSTONE TO BE
400x100x215mm

INDICATES STRIP FOUNDATION
600x300mm MINIMUM TO REACH
SUITABLE STRATA (GBP 100kN/m2)

INDICATES PAD FOUNDATION
1000x1000x300mm MINIMUM TO
REACH SUITABLE STRATA (GBP
100kN/m2)



GROUND FLOOR / FOUNDATIONS

GLAZING CORNER TO BE
DESIGNED BY SPECIALIST,
IT SHOULD BE DESIGNED TO
SUPPORT THE PITCHED
ROOF ON TOP.

INDICATES
152x152x23UC
COLUMN (3no)

CONCRETE LINTEL
BY SPECIALIST.

UC 203x203x46 with 10mm THICK
PLATE ON TOP TO SUIT
THICKNESS OF WALL. (BEAM B)

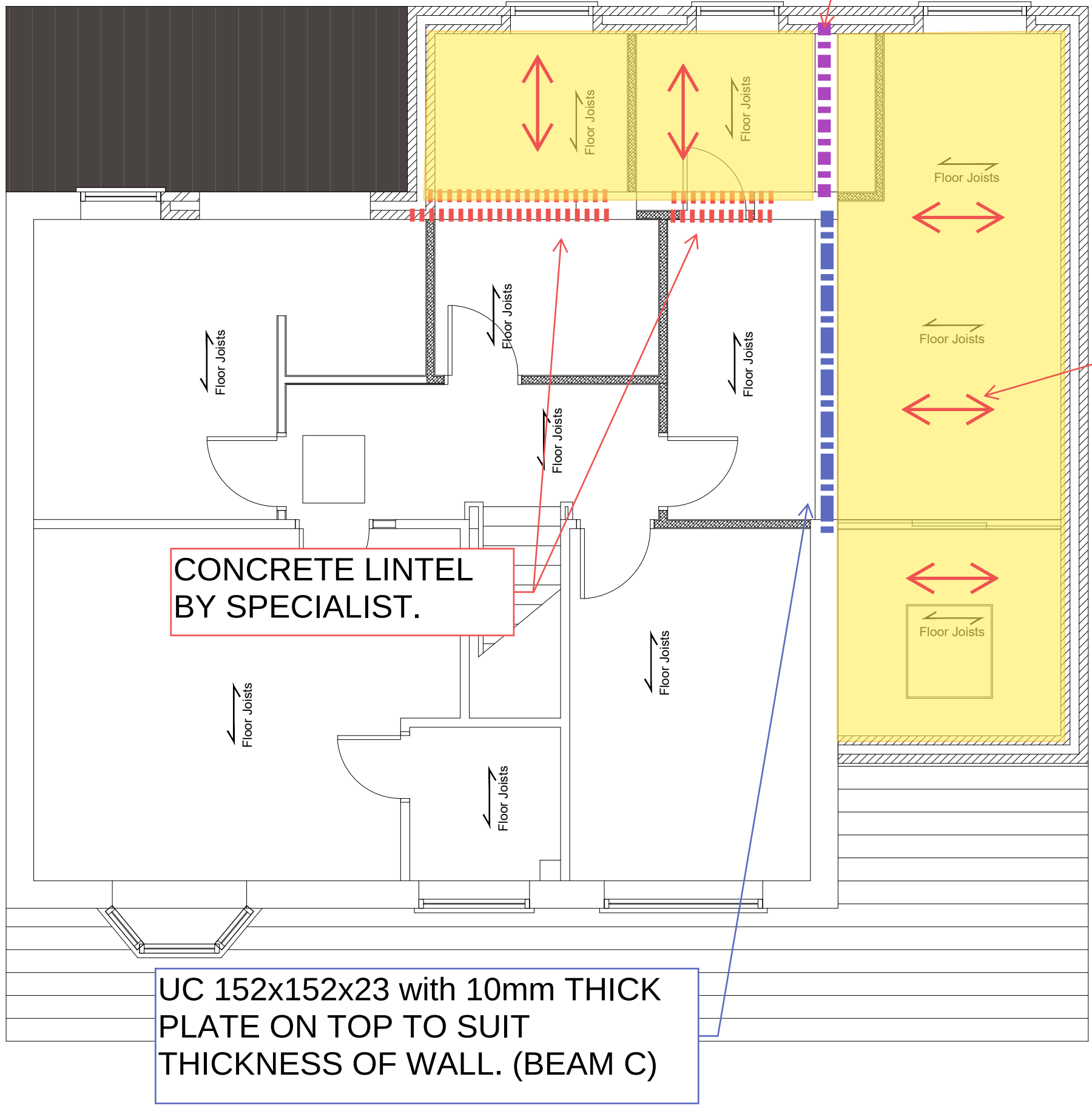
UC 254x254x73 with 10mm THICK
PLATE ON TOP TO SUIT
THICKNESS OF WALL. (BEAM A)

UC 203x203x46 with 10mm THICK
PLATE ON TOP TO SUIT
THICKNESS OF WALL. (BEAM C)

CONCRETE LINTEL
BY SPECIALIST.

CONCRETE LINTEL
BY SPECIALIST.

GROUND FLOOR /
STEEL LAYOUT BELOW
1st FLOOR



1ST FLOOR / STEEL
LAYOUT ABOVE 1st
FLOOR

INDICATES LOAD
BEARING WALL BELOW.

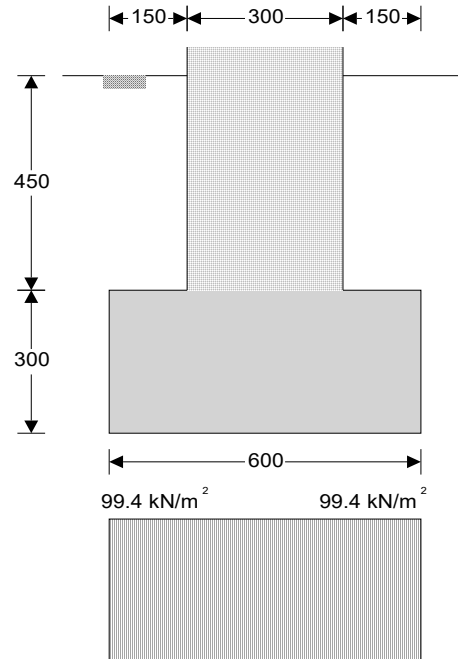
INDICATES TIMBER JOISTS
C16 44x170mm @ 450mm

CONCRETE LINTEL
BY SPECIALIST.

UC 152x152x23 with 10mm THICK
PLATE ON TOP TO SUIT
THICKNESS OF WALL. (BEAM C)

STRIP FOOTING ANALYSIS AND DESIGN (BS8110-1:1997)

Tedds calculation version 2.0.07



Strip footing details

Width of strip footing

$B = 600 \text{ mm}$

Depth of strip footing

$h = 300 \text{ mm}$

Depth of soil over strip footing

$h_{\text{soil}} = 450 \text{ mm}$

Density of concrete

$\rho_{\text{conc}} = 23.6 \text{ kN/m}^3$

Load details

Load width

$b = 300 \text{ mm}$

Load eccentricity

$e_P = 0 \text{ mm}$

Soil details

Density of soil

$\rho_{\text{soil}} = 20.0 \text{ kN/m}^3$

Design shear strength

$\phi' = 25.0 \text{ deg}$

Design base friction

$\delta = 19.3 \text{ deg}$

Allowable bearing pressure

$P_{\text{bearing}} = 100 \text{ kN/m}^2$

Axial loading on strip footing

Dead axial load

$P_G = 35.0 \text{ kN/m}$

Imposed axial load

$P_Q = 15.0 \text{ kN/m}$

Wind axial load

$P_W = 0.0 \text{ kN/m}$

Total axial load

$P = 50.0 \text{ kN/m}$

Foundation loads

Dead surcharge load

$F_{G_{\text{sur}}} = 0.000 \text{ kN/m}^2$

Imposed surcharge load

$F_{Q_{\text{sur}}} = 0.000 \text{ kN/m}^2$

Strip footing self weight

$F_{\text{swt}} = h \times \rho_{\text{conc}} = 7.080 \text{ kN/m}^2$

Soil self weight

$F_{\text{soil}} = h_{\text{soil}} \times \rho_{\text{soil}} = 9.000 \text{ kN/m}^2$

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for TYPICAL STRIP FOUNDATION				Start page no./Revision 2	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Total foundation load

$$F = B \times (F_{Gsur} + F_{Qsur} + F_{swt} + F_{soil}) = \mathbf{9.6 \text{ kN/m}}$$

Calculate base reaction

Total base reaction

$$T = F + P = \mathbf{59.6 \text{ kN/m}}$$

Eccentricity of base reaction in x

$$e_T = (P \times e_P + M + H \times h) / T = \mathbf{0 \text{ mm}}$$

Base reaction acts within middle third of base

Calculate base pressures

$$q_1 = (T / B) \times (1 - 6 \times e_T / B) = \mathbf{99.413 \text{ kN/m}^2}$$

$$q_2 = (T / B) \times (1 + 6 \times e_T / B) = \mathbf{99.413 \text{ kN/m}^2}$$

Minimum base pressure

$$q_{min} = \min(q_1, q_2) = \mathbf{99.413 \text{ kN/m}^2}$$

Maximum base pressure

$$q_{max} = \max(q_1, q_2) = \mathbf{99.413 \text{ kN/m}^2}$$

PASS - Maximum base pressure is less than allowable bearing pressure

Material details

Characteristic strength of concrete

$$f_{cu} = \mathbf{30 \text{ N/mm}^2}$$

Calculate base lengths

Left hand length

$$B_L = B / 2 + e_P = \mathbf{300 \text{ mm}}$$

Right hand length

$$B_R = B / 2 - e_P = \mathbf{300 \text{ mm}}$$

Calculate rate of change of base pressure

Length of base reaction

$$B_x = B = \mathbf{600 \text{ mm}}$$

Rate of change of base pressure

$$C_x = (q_1 - q_2) / B_x = \mathbf{0.000 \text{ kN/m}^2/\text{m}}$$

Calculate minimum depth of unreinforced strip footing

Average pressure to left of strip footing

$$q_L = q_1 - C_x \times (B_L - b / 2) / 2 = \mathbf{99.413 \text{ kN/m}^2}$$

Minimum depth to left of strip footing

$$h_{Lmin} = (B_L - b / 2) \times \max(0.15 \times [(q_L / 1 \text{ kN/m}^2) / (f_{cu} / 1 \text{ N/mm}^2)]^{1/4}, 1) = \mathbf{150 \text{ mm}}$$

Average pressure to right of strip footing

$$q_R = q_2 + C_x \times (B_R - b / 2) / 2 = \mathbf{99.413 \text{ kN/m}^2}$$

Minimum depth to right of strip footing

$$h_{Rmin} = (B_R - b / 2) \times \max(0.15 \times [(q_R / 1 \text{ kN/m}^2) / (f_{cu} / 1 \text{ N/mm}^2)]^{1/4}, 1) = \mathbf{150 \text{ mm}}$$

Minimum depth of unreinforced strip footing

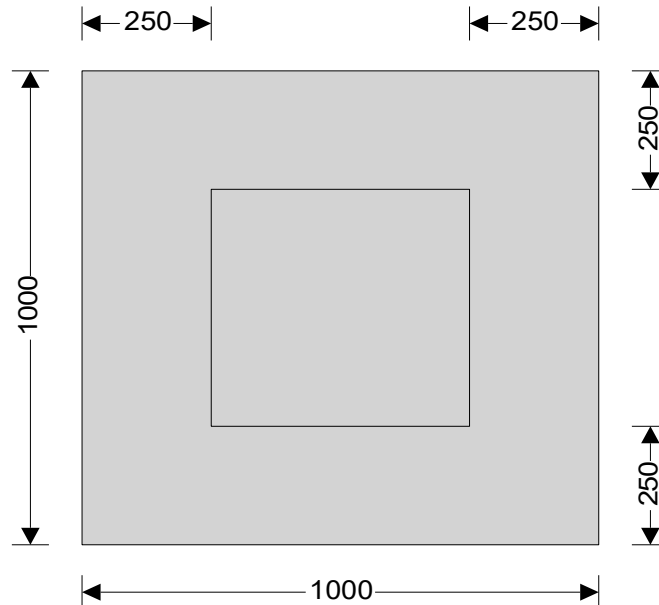
$$h_{min} = \max(h_{Lmin}, h_{Rmin}, 300 \text{ mm}) = \mathbf{300 \text{ mm}}$$

PASS - Unreinforced strip footing depth is greater than minimum

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for TYPICAL PAD FOUNDATION				Start page no./Revision 1	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

PAD FOOTING ANALYSIS AND DESIGN (BS8110-1:1997)

Tedds calculation version 2.0.07



Pad footing details

Length of pad footing	$L = 1000$ mm
Width of pad footing	$B = 1000$ mm
Area of pad footing	$A = L \times B = 1.000$ m ²
Depth of pad footing	$h = 300$ mm
Depth of soil over pad footing	$h_{\text{soil}} = 200$ mm
Density of concrete	$\rho_{\text{conc}} = 23.6$ kN/m ³

Column details

Column base length	$l_A = 500$ mm
Column base width	$b_A = 500$ mm
Column eccentricity in x	$e_{Px} = 0$ mm
Column eccentricity in y	$e_{Py} = 0$ mm

Soil details

Density of soil	$\rho_{\text{soil}} = 20.0$ kN/m ³
Design shear strength	$\phi' = 25.0$ deg
Design base friction	$\delta = 19.3$ deg
Allowable bearing pressure	$P_{\text{bearing}} = 100$ kN/m ²

Axial loading on column

Dead axial load on column	$P_{GA} = 69.0$ kN
Imposed axial load on column	$P_{QA} = 19.0$ kN
Wind axial load on column	$P_{WA} = 0.0$ kN
Total axial load on column	$P_A = 88.0$ kN

Foundation loads

Dead surcharge load	$F_{G\text{sur}} = 0.000$ kN/m ²
Imposed surcharge load	$F_{Q\text{sur}} = 0.000$ kN/m ²

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for TYPICAL PAD FOUNDATION				Start page no./Revision 2	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Pad footing self weight

$$F_{\text{swt}} = h \times \rho_{\text{conc}} = 7.080 \text{ kN/m}^2$$

Soil self weight

$$F_{\text{soil}} = h_{\text{soil}} \times \rho_{\text{soil}} = 4.000 \text{ kN/m}^2$$

Total foundation load

$$F = A \times (F_{\text{Gsur}} + F_{\text{Qsur}} + F_{\text{swt}} + F_{\text{soil}}) = 11.1 \text{ kN}$$

Calculate pad base reaction

Total base reaction

$$T = F + P_A = 99.1 \text{ kN}$$

Eccentricity of base reaction in x

$$e_{Tx} = (P_A \times e_{Px} + M_{xA} + H_{xA} \times h) / T = 0 \text{ mm}$$

Eccentricity of base reaction in y

$$e_{Ty} = (P_A \times e_{Py} + M_{yA} + H_{yA} \times h) / T = 0 \text{ mm}$$

Check pad base reaction eccentricity

$$\text{abs}(e_{Tx}) / L + \text{abs}(e_{Ty}) / B = 0.000$$

Base reaction acts within middle third of base

Calculate pad base pressures

$$q_1 = T / A - 6 \times T \times e_{Tx} / (L \times A) - 6 \times T \times e_{Ty} / (B \times A) = 99.080 \text{ kN/m}^2$$

$$q_2 = T / A - 6 \times T \times e_{Tx} / (L \times A) + 6 \times T \times e_{Ty} / (B \times A) = 99.080 \text{ kN/m}^2$$

$$q_3 = T / A + 6 \times T \times e_{Tx} / (L \times A) - 6 \times T \times e_{Ty} / (B \times A) = 99.080 \text{ kN/m}^2$$

$$q_4 = T / A + 6 \times T \times e_{Tx} / (L \times A) + 6 \times T \times e_{Ty} / (B \times A) = 99.080 \text{ kN/m}^2$$

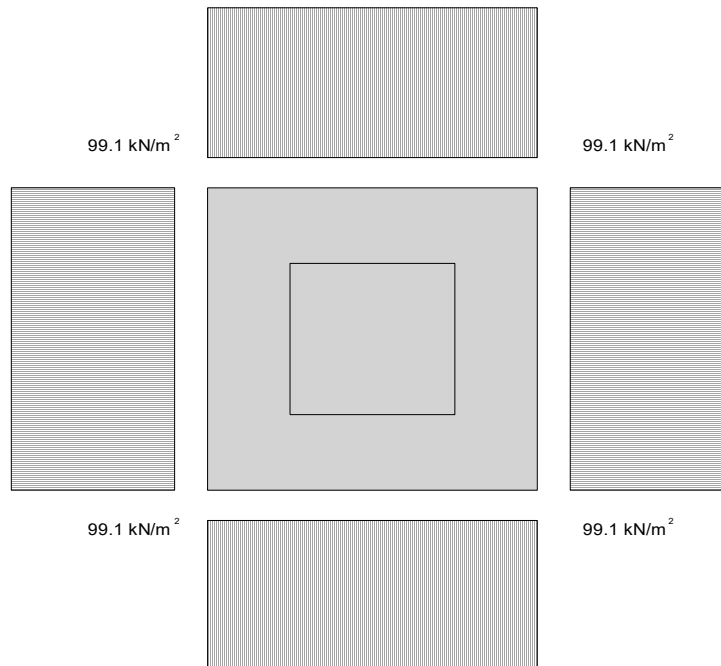
Minimum base pressure

$$q_{\text{min}} = \min(q_1, q_2, q_3, q_4) = 99.080 \text{ kN/m}^2$$

Maximum base pressure

$$q_{\text{max}} = \max(q_1, q_2, q_3, q_4) = 99.080 \text{ kN/m}^2$$

PASS - Maximum base pressure is less than allowable bearing pressure



Material details

Characteristic strength of concrete

$$f_{cu} = 30 \text{ N/mm}^2$$

Calculate pad lengths in x direction

Left hand length

$$L_L = L / 2 + e_{Px} = 500 \text{ mm}$$

Right hand length

$$L_R = L / 2 - e_{Px} = 500 \text{ mm}$$

Calculate rate of change of base pressure in x direction

Length of base reaction

$$L_x = L = 1000 \text{ mm}$$

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for TYPICAL PAD FOUNDATION				Start page no./Revision 3	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Rate of change of base pressure

$$C_x = [(q_1 + q_2) - (q_3 + q_4)] / (2 \times L_x) = \mathbf{0.000 \text{ kN/m}^2/\text{m}}$$

Calculate pad lengths in y direction

Top length

$$L_T = B / 2 - e_{PyA} = \mathbf{500 \text{ mm}}$$

Bottom length

$$L_B = B / 2 + e_{PyA} = \mathbf{500 \text{ mm}}$$

Calculate rate of change of base pressure in y direction

Length of base reaction

$$L_y = B = \mathbf{1000 \text{ mm}}$$

Rate of change of base pressure

$$C_y = [(q_1 + q_3) - (q_2 + q_4)] / (2 \times L_y) = \mathbf{0.000 \text{ kN/m}^2/\text{m}}$$

Calculate minimum depth of unreinforced pad footing

Average pressure to left of pad footing

$$q_L = (q_1 + q_2) / 2 - C_x \times (L_L - l_A / 2) / 2 = \mathbf{99.080 \text{ kN/m}^2}$$

Minimum depth to left of pad footing

$$h_{Lmin} = (L_L - l_A / 2) \times \max(0.15 \times [(q_L / 1 \text{ kN/m}^2)^2 / (f_{cu} / 1 \text{ N/mm}^2)]^{1/4}, 1) = \mathbf{250 \text{ mm}}$$

Average pressure to right of pad footing

$$q_R = (q_3 + q_4) / 2 - C_x \times (L_R - l_A / 2) / 2 = \mathbf{99.080 \text{ kN/m}^2}$$

Minimum depth to right of pad footing

$$h_{Rmin} = (L_R - l_A / 2) \times \max(0.15 \times [(q_R / 1 \text{ kN/m}^2)^2 / (f_{cu} / 1 \text{ N/mm}^2)]^{1/4}, 1) = \mathbf{250 \text{ mm}}$$

Average pressure to top of pad footing

$$q_T = (q_2 + q_4) / 2 - C_y \times (L_T - b_A / 2) / 2 = \mathbf{99.080 \text{ kN/m}^2}$$

Minimum depth to top of pad footing

$$h_{Tmin} = (L_T - b_A / 2) \times \max(0.15 \times [(q_T / 1 \text{ kN/m}^2)^2 / (f_{cu} / 1 \text{ N/mm}^2)]^{1/4}, 1) = \mathbf{250 \text{ mm}}$$

Average pressure to bottom of pad footing

$$q_B = (q_1 + q_3) / 2 - C_y \times (L_B - b_A / 2) / 2 = \mathbf{99.080 \text{ kN/m}^2}$$

Minimum depth to bottom of pad footing

$$h_{Bmin} = (L_B - b_A / 2) \times \max(0.15 \times [(q_B / 1 \text{ kN/m}^2)^2 / (f_{cu} / 1 \text{ N/mm}^2)]^{1/4}, 1) = \mathbf{250 \text{ mm}}$$

Minimum depth of unreinforced pad footing

$$h_{min} = \max(h_{Lmin}, h_{Rmin}, h_{Tmin}, h_{Bmin}, 300 \text{ mm}) = \mathbf{300 \text{ mm}}$$

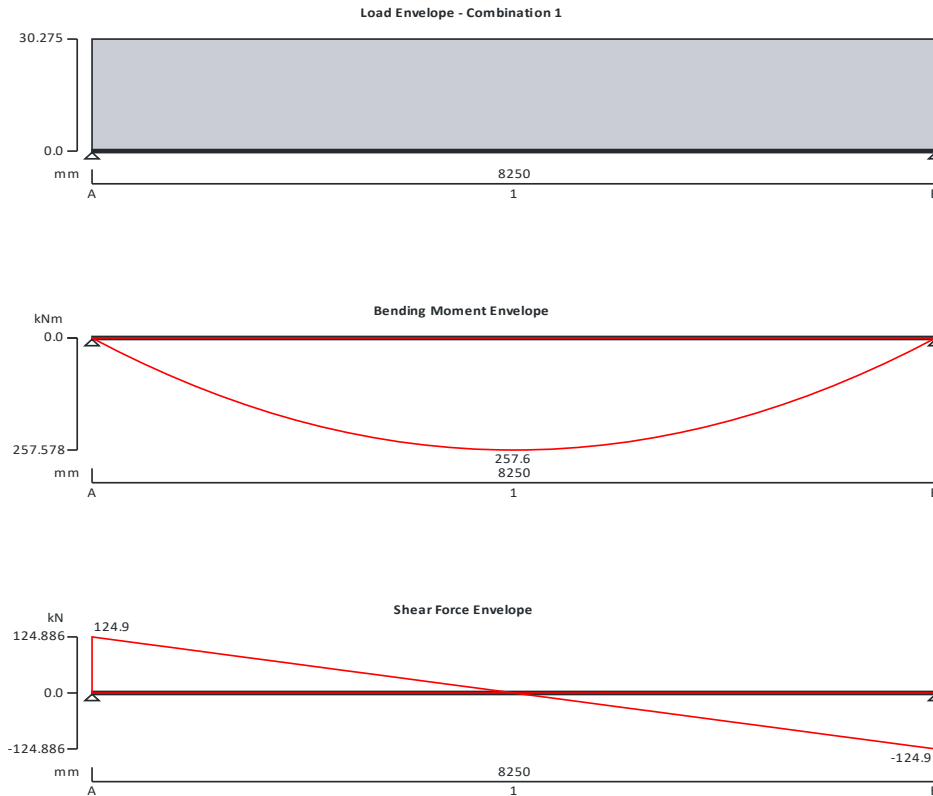
PASS - Unreinforced pad footing depth is greater than minimum

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM A				Start page no./Revision 1	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

STEEL BEAM ANALYSIS & DESIGN (BS5950)

In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.07



Support conditions

Support A

Vertically restrained

Rotationally free

Support B

Vertically restrained

Rotationally free

Applied loading

Beam loads

Dead self weight of beam $\times 1$

1st floor - Dead full UDL 1.5 kN/m

1st floor - Imposed full UDL 2.65 kN/m

Roof - Dead full UDL 2.65 kN/m

Roof - Imposed full UDL 1.5 kN/m

Wall (2leaves) - Dead full UDL 12 kN/m

Load combinations

Load combination 1

Support A

Dead $\times 1.40$

Imposed $\times 1.60$

Dead $\times 1.40$

Imposed $\times 1.60$

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM A				Start page no./Revision 2	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Support B

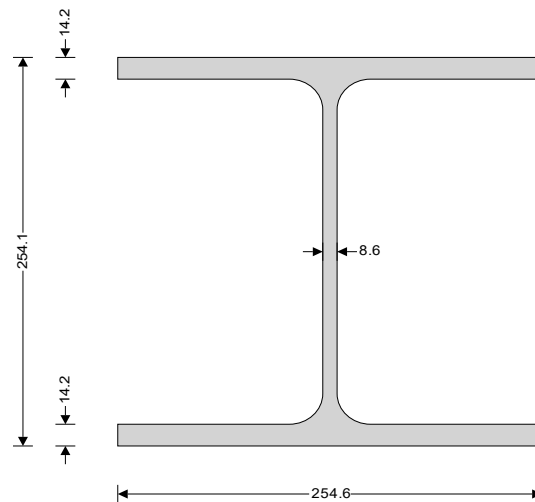
Dead × 1.40
Imposed × 1.60

Analysis results

Maximum moment	$M_{max} = 257.6 \text{ kNm}$	$M_{min} = 0 \text{ kNm}$
Maximum moment span 1 segment 1	$M_{s1_seg1_max} = 257.6 \text{ kNm}$	$M_{s1_seg1_min} = 0 \text{ kNm}$
Maximum moment span 1 segment 2	$M_{s1_seg2_max} = 257.6 \text{ kNm}$	$M_{s1_seg2_min} = 0 \text{ kNm}$
Maximum shear	$V_{max} = 124.9 \text{ kN}$	$V_{min} = -124.9 \text{ kN}$
Maximum shear span 1 segment 1	$V_{s1_seg1_max} = 124.9 \text{ kN}$	$V_{s1_seg1_min} = 0 \text{ kN}$
Maximum shear span 1 segment 2	$V_{s1_seg2_max} = 0 \text{ kN}$	$V_{s1_seg2_min} = -124.9 \text{ kN}$
Deflection segment 3	$\delta_{max} = 10.5 \text{ mm}$	$\delta_{min} = 0 \text{ mm}$
Maximum reaction at support A	$R_{A_max} = 124.9 \text{ kN}$	$R_{A_min} = 124.9 \text{ kN}$
Unfactored dead load reaction at support A	$R_{A_Dead} = 69.6 \text{ kN}$	
Unfactored imposed load reaction at support A	$R_{A_Imposed} = 17.1 \text{ kN}$	
Maximum reaction at support B	$R_{B_max} = 124.9 \text{ kN}$	$R_{B_min} = 124.9 \text{ kN}$
Unfactored dead load reaction at support B	$R_{B_Dead} = 69.6 \text{ kN}$	
Unfactored imposed load reaction at support B	$R_{B_Imposed} = 17.1 \text{ kN}$	

Section details

Section type	UC 254x254x73 (British Steel Section Range 2022 (BS4-1))
Steel grade	S355
From table 9: Design strength p_y	
Thickness of element	$\max(T, t) = 14.2 \text{ mm}$
Design strength	$p_y = 355 \text{ N/mm}^2$
Modulus of elasticity	$E = 205000 \text{ N/mm}^2$



Lateral restraint

Span 1 has lateral restraint at supports plus midspan

Effective length factors

Effective length factor in major axis	$K_x = 1.00$
Effective length factor in minor axis	$K_y = 1.00$
Effective length factor for lateral-torsional buckling	$K_{LT.A} = 1.00$
	$K_{LT.B} = 1.00$

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM A				Start page no./Revision 3	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Classification of cross sections - Section 3.5

$$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]} = \mathbf{0.88}$$

Internal compression parts - Table 11

Depth of section

$$d = \mathbf{185.7 \text{ mm}}$$

$$d / t = 24.5 \times \varepsilon \leq 80 \times \varepsilon \quad \text{Class 1 plastic}$$

Outstand flanges - Table 11

Width of section

$$b = B / 2 = \mathbf{127.3 \text{ mm}}$$

$$b / T = 10.2 \times \varepsilon \leq 15 \times \varepsilon \quad \text{Class 3 semi-compact}$$

Section is class 3 semi-compact

Shear capacity - Section 4.2.3

Design shear force

$$F_v = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = \mathbf{124.9 \text{ kN}}$$

$$d / t < 70 \times \varepsilon$$

Web does not need to be checked for shear buckling

Shear area

$$A_v = t \times D = \mathbf{2185 \text{ mm}^2}$$

Design shear resistance

$$P_v = 0.6 \times p_y \times A_v = \mathbf{465.5 \text{ kN}}$$

PASS - Design shear resistance exceeds design shear force

Moment capacity at span 1 segment 1 - Section 4.2.5

Design bending moment

$$M = \max(\text{abs}(M_{s1_seg1_max}), \text{abs}(M_{s1_seg1_min})) = \mathbf{257.6 \text{ kNm}}$$

Effective plastic modulus - Section 3.5.6

Limiting value for class 2 compact flange

$$\beta_{2f} = 10 \times \varepsilon = \mathbf{8.801}$$

Limiting value for class 3 semi-compact flange

$$\beta_{3f} = 15 \times \varepsilon = \mathbf{13.202}$$

Limiting value for class 2 compact web

$$\beta_{2w} = 100 \times \varepsilon = \mathbf{88.014}$$

Limiting value for class 3 semi-compact web

$$\beta_{3w} = 120 \times \varepsilon = \mathbf{105.617}$$

Effective plastic modulus - cl.3.5.6.2

$$S_{\text{eff}} = \min(Z_{xx} + (S_{xx} - Z_{xx}) \times \min([((\beta_{3w} / (d / t))^2 - 1] / ((\beta_{3w} / \beta_{2w})^2 - 1)], [(\beta_{3f} / (b / T) - 1) / (\beta_{3f} / \beta_{2f} - 1)]), S_{xx}) = \mathbf{1008717 \text{ mm}^3}$$

Moment capacity low shear - cl.4.2.5.2

$$M_c = \min(p_y \times S_{\text{eff}}, 1.2 \times p_y \times Z_{xx}) = \mathbf{358.1 \text{ kNm}}$$

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling

$$L_E = 1.0 \times L_{s1_seg1} = \mathbf{4125 \text{ mm}}$$

Slenderness ratio

$$\lambda = L_E / r_{yy} = \mathbf{64.348}$$

Equivalent slenderness - Section 4.3.6.7

Buckling parameter

$$u = \mathbf{0.851}$$

Torsional index

$$x = \mathbf{16.290}$$

Slenderness factor

$$v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25} = \mathbf{0.866}$$

Ratio - cl.4.3.6.9

$$\beta_w = S_{\text{eff}} / S_{xx} = \mathbf{0.995}$$

Equivalent slenderness - cl.4.3.6.7

$$\lambda_{LT} = u \times v \times \lambda \times \sqrt{\beta_w} = \mathbf{47.279}$$

Limiting slenderness - Annex B.2.2

$$\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5} = \mathbf{30.198}$$

$\lambda_{LT} > \lambda_{L0}$ - Allowance should be made for lateral-torsional buckling

Bending strength - Section 4.3.6.5

Robertson constant

$$\alpha_{LT} = \mathbf{7.0}$$

Perry factor

$$\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) = \mathbf{0.120}$$

Euler stress

$$p_E = \pi^2 \times E / \lambda_{LT}^2 = \mathbf{905.1 \text{ N/mm}^2}$$

$$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 = \mathbf{684.2 \text{ N/mm}^2}$$

Bending strength - Annex B.2.1

$$p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) = \mathbf{301.1 \text{ N/mm}^2}$$

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM A				Start page no./Revision 4	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment $M_2 = 112.7$ kNm

Moment at centre-line of segment $M_3 = 193.2$ kNm

Moment at three quarter point of segment $M_4 = 241.5$ kNm

Maximum moment in segment $M_{abs} = 257.6$ kNm

Maximum moment governing buckling resistance $M_{LT} = M_{abs} = 257.6$ kNm

Equivalent uniform moment factor for lateral-torsional buckling

$$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44) = 0.781$$

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment $M_b = p_b \times S_{eff} = 303.7$ kNm

$$M_b / m_{LT} = 388.7 \text{ kNm}$$

PASS - Moment capacity exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to imposed loads

Limiting deflection $\delta_{lim} = L_{s1} / 360 = 22.917$ mm

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = 10.487$ mm

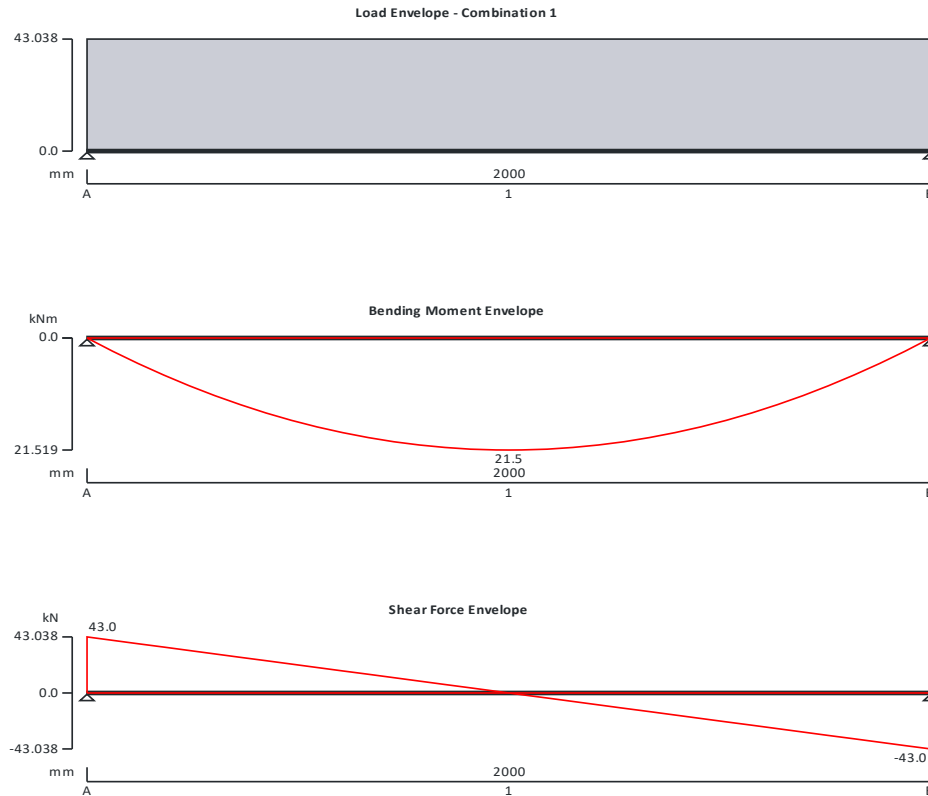
PASS - Maximum deflection does not exceed deflection limit

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM B				Start page no./Revision 1	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

STEEL BEAM ANALYSIS & DESIGN (BS5950)

In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.07



Support conditions

Support A

Vertically restrained

Rotationally free

Support B

Vertically restrained

Rotationally free

Applied loading

Beam loads

Dead self weight of beam $\times 1$

roof - Dead full UDL 10.5 kN/m

roof - Imposed full UDL 5.5 kN/m

wall - Dead full UDL 13.5 kN/m

Load combinations

Load combination 1

Support A

Dead $\times 1.40$

Imposed $\times 1.60$

Dead $\times 1.40$

Imposed $\times 1.60$

Support B

Dead $\times 1.40$

Imposed $\times 1.60$

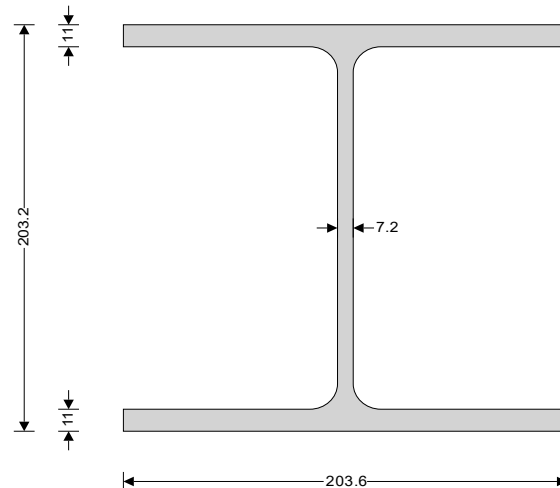
Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM B				Start page no./Revision 2	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Analysis results

Maximum moment	$M_{max} = 21.5 \text{ kNm}$	$M_{min} = 0 \text{ kNm}$
Maximum shear	$V_{max} = 43 \text{ kN}$	$V_{min} = -43 \text{ kN}$
Deflection	$\delta_{max} = 0.1 \text{ mm}$	$\delta_{min} = 0 \text{ mm}$
Maximum reaction at support A	$R_{A_max} = 43 \text{ kN}$	$R_{A_min} = 43 \text{ kN}$
Unfactored dead load reaction at support A	$R_{A_Dead} = 24.5 \text{ kN}$	
Unfactored imposed load reaction at support A	$R_{A_Imposed} = 5.5 \text{ kN}$	
Maximum reaction at support B	$R_{B_max} = 43 \text{ kN}$	$R_{B_min} = 43 \text{ kN}$
Unfactored dead load reaction at support B	$R_{B_Dead} = 24.5 \text{ kN}$	
Unfactored imposed load reaction at support B	$R_{B_Imposed} = 5.5 \text{ kN}$	

Section details

Section type	UC 203x203x46 (British Steel Section Range 2022 (BS4-1))
Steel grade	S355
From table 9: Design strength p_y	
Thickness of element	$\max(T, t) = 11.0 \text{ mm}$
Design strength	$p_y = 355 \text{ N/mm}^2$
Modulus of elasticity	$E = 205000 \text{ N/mm}^2$



Lateral restraint

Span 1 has lateral restraint at supports only

Effective length factors

Effective length factor in major axis	$K_x = 1.00$
Effective length factor in minor axis	$K_y = 1.00$
Effective length factor for lateral-torsional buckling	$K_{LTA} = 1.00$
	$K_{LTB} = 1.00$

Classification of cross sections - Section 3.5

$$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]} = 0.88$$

Internal compression parts - Table 11

Depth of section	$d = 155.8 \text{ mm}$	
	$d / t = 24.6 \times \varepsilon \leq 80 \times \varepsilon$	Class 1 plastic

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM B				Start page no./Revision 3	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Outstand flanges - Table 11

Width of section $b = B / 2 = 101.8 \text{ mm}$
 $b / T = 10.5 \times \varepsilon \leq 15 \times \varepsilon$ Class 3 semi-compact
Section is class 3 semi-compact

Shear capacity - Section 4.2.3

Design shear force $F_v = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 43 \text{ kN}$
 $d / t < 70 \times \varepsilon$
Web does not need to be checked for shear buckling
 Shear area $A_v = t \times D = 1463 \text{ mm}^2$
 Design shear resistance $P_v = 0.6 \times p_y \times A_v = 311.6 \text{ kN}$
PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment $M = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = 21.5 \text{ kNm}$

Effective plastic modulus - Section 3.5.6

Limiting value for class 2 compact flange $\beta_{2f} = 10 \times \varepsilon = 8.801$
 Limiting value for class 3 semi-compact flange $\beta_{3f} = 15 \times \varepsilon = 13.202$
 Limiting value for class 2 compact web $\beta_{2w} = 100 \times \varepsilon = 88.014$
 Limiting value for class 3 semi-compact web $\beta_{3w} = 120 \times \varepsilon = 105.617$
 Effective plastic modulus - cl.3.5.6.2
 $S_{\text{eff}} = \min(Z_{xx} + (S_{xx} - Z_{xx}) \times \min(\frac{((\beta_{3w} / (d / t))^2 - 1)}{((\beta_{3w} / \beta_{2w})^2 - 1)}, \frac{[(\beta_{3f} / (b / T) - 1) / (\beta_{3f} / \beta_{2f} - 1)]}{1}), S_{xx}) = 494583 \text{ mm}^3$
 Moment capacity low shear - cl.4.2.5.2 $M_c = \min(p_y \times S_{\text{eff}}, 1.2 \times p_y \times Z_{xx}) = 175.6 \text{ kNm}$

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling $L_E = 1.0 \times L_{s1} = 2000 \text{ mm}$
 Slenderness ratio $\lambda = L_E / r_{yy} = 39.113$

Equivalent slenderness - Section 4.3.6.7

Buckling parameter $u = 0.847$
 Torsional index $x = 17.327$
 Slenderness factor $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25} = 0.945$
 Ratio - cl.4.3.6.9 $\beta_W = S_{\text{eff}} / S_{xx} = 0.986$
 Equivalent slenderness - cl.4.3.6.7 $\lambda_{LT} = u \times v \times \lambda \times \sqrt{\beta_W} = 31.095$
 Limiting slenderness - Annex B.2.2 $\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5} = 30.198$
 $\lambda_{LT} > \lambda_{L0}$ - Allowance should be made for lateral-torsional buckling

Bending strength - Section 4.3.6.5

Robertson constant $\alpha_{LT} = 7.0$
 Perry factor $\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) = 0.006$
 Euler stress $p_E = \pi^2 \times E / \lambda_{LT}^2 = 2092.6 \text{ N/mm}^2$
 $\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 = 1230.4 \text{ N/mm}^2$
 Bending strength - Annex B.2.1 $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) = 352.3 \text{ N/mm}^2$

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment $M_2 = 16.1 \text{ kNm}$
 Moment at centre-line of segment $M_3 = 21.5 \text{ kNm}$
 Moment at three quarter point of segment $M_4 = 16.1 \text{ kNm}$
 Maximum moment in segment $M_{\text{abs}} = 21.5 \text{ kNm}$
 Maximum moment governing buckling resistance $M_{LT} = M_{\text{abs}} = 21.5 \text{ kNm}$

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM B				Start page no./Revision 4	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Equivalent uniform moment factor for lateral-torsional buckling

$$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44) = \mathbf{0.925}$$

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment

$$M_b = p_b \times S_{eff} = \mathbf{174.3 \text{ kNm}}$$

$$M_b / m_{LT} = \mathbf{188.4 \text{ kNm}}$$

PASS - Moment capacity exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to imposed loads

Limiting deflection

$$\delta_{lim} = L_{s1} / 360 = \mathbf{5.556 \text{ mm}}$$

Maximum deflection span 1

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.121 \text{ mm}}$$

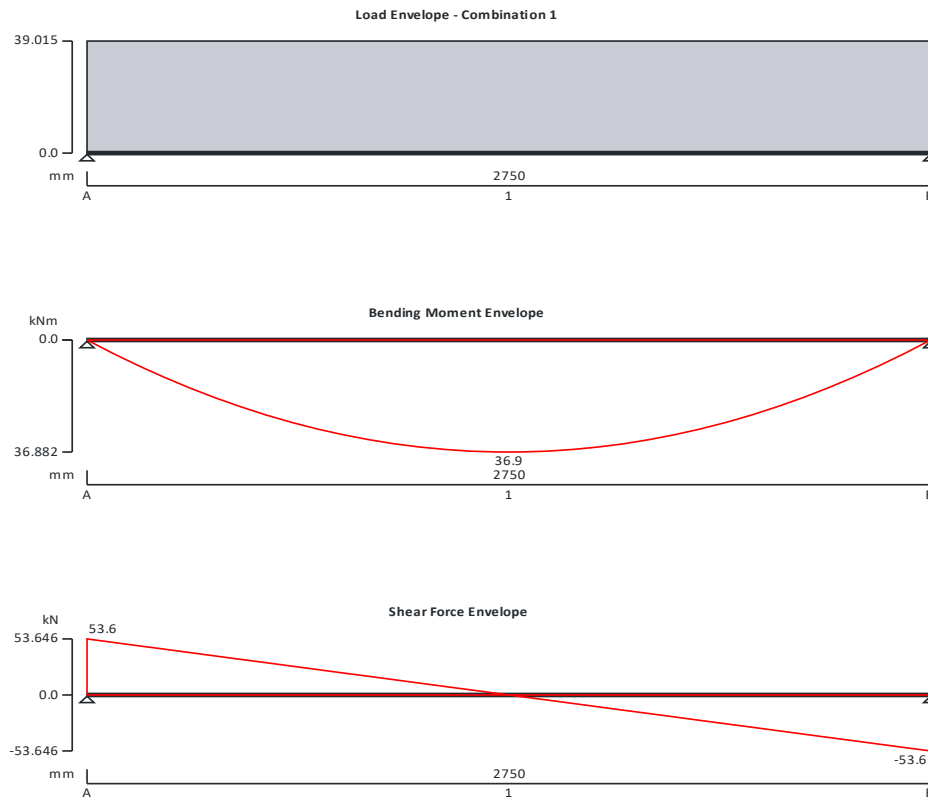
PASS - Maximum deflection does not exceed deflection limit

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM C				Start page no./Revision 1	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

STEEL BEAM ANALYSIS & DESIGN (BS5950)

In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.07



Support conditions

Support A

Vertically restrained

Rotationally free

Support B

Vertically restrained

Rotationally free

Applied loading

Beam loads

Dead self weight of beam $\times 1$

roof - Dead full UDL 9 kN/m

roof - Imposed full UDL 4.5 kN/m

wall - Dead full UDL 13.5 kN/m

Load combinations

Load combination 1

Support A

Dead $\times 1.40$

Imposed $\times 1.60$

Dead $\times 1.40$

Imposed $\times 1.60$

Support B

Dead $\times 1.40$

Imposed $\times 1.60$

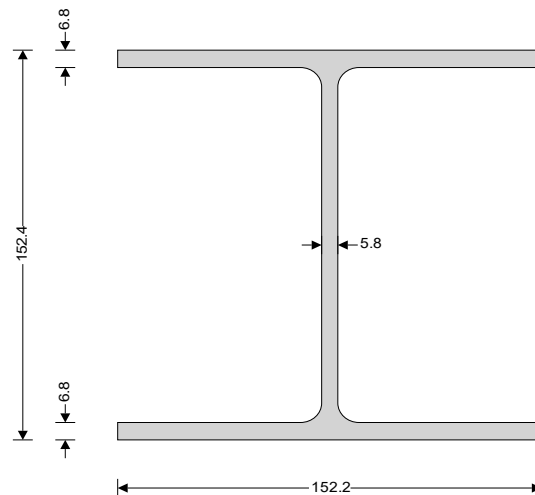
Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM C				Start page no./Revision 2	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Analysis results

Maximum moment	$M_{max} = 36.9 \text{ kNm}$	$M_{min} = 0 \text{ kNm}$
Maximum shear	$V_{max} = 53.6 \text{ kN}$	$V_{min} = -53.6 \text{ kN}$
Deflection	$\delta_{max} = 1.3 \text{ mm}$	$\delta_{min} = 0 \text{ mm}$
Maximum reaction at support A	$R_{A_{max}} = 53.6 \text{ kN}$	$R_{A_{min}} = 53.6 \text{ kN}$
Unfactored dead load reaction at support A	$R_{A_{Dead}} = 31.2 \text{ kN}$	
Unfactored imposed load reaction at support A	$R_{A_{Imposed}} = 6.2 \text{ kN}$	
Maximum reaction at support B	$R_{B_{max}} = 53.6 \text{ kN}$	$R_{B_{min}} = 53.6 \text{ kN}$
Unfactored dead load reaction at support B	$R_{B_{Dead}} = 31.2 \text{ kN}$	
Unfactored imposed load reaction at support B	$R_{B_{Imposed}} = 6.2 \text{ kN}$	

Section details

Section type	UC 152x152x23 (British Steel Section Range 2022 (BS4-1))
Steel grade	S355
From table 9: Design strength p_y	
Thickness of element	$\max(T, t) = 6.8 \text{ mm}$
Design strength	$p_y = 355 \text{ N/mm}^2$
Modulus of elasticity	$E = 205000 \text{ N/mm}^2$



Lateral restraint

Span 1 has lateral restraint at supports only

Effective length factors

Effective length factor in major axis	$K_x = 1.00$
Effective length factor in minor axis	$K_y = 1.00$
Effective length factor for lateral-torsional buckling	$K_{LTA} = 1.00 + 2 \times D$
	$K_{LTB} = 1.00 + 2 \times D$

Classification of cross sections - Section 3.5

$$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]} = 0.88$$

Internal compression parts - Table 11

Depth of section	$d = 123.6 \text{ mm}$	
	$d / t = 24.2 \times \varepsilon \leq 80 \times \varepsilon$	Class 1 plastic

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM C				Start page no./Revision 3	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Outstand flanges - Table 11

Width of section

$$b = B / 2 = 76.1 \text{ mm}$$

$$b / T = 12.7 \times \varepsilon \leq 15 \times \varepsilon$$

Class 3 semi-compact

Section is class 3 semi-compact

Shear capacity - Section 4.2.3

Design shear force

$$F_v = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 53.6 \text{ kN}$$

$$d / t < 70 \times \varepsilon$$

Web does not need to be checked for shear buckling

Shear area

$$A_v = t \times D = 884 \text{ mm}^2$$

Design shear resistance

$$P_v = 0.6 \times p_y \times A_v = 188.3 \text{ kN}$$

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment

$$M = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = 36.9 \text{ kNm}$$

Effective plastic modulus - Section 3.5.6

Limiting value for class 2 compact flange

$$\beta_{2f} = 10 \times \varepsilon = 8.801$$

Limiting value for class 3 semi-compact flange

$$\beta_{3f} = 15 \times \varepsilon = 13.202$$

Limiting value for class 2 compact web

$$\beta_{2w} = 100 \times \varepsilon = 88.014$$

Limiting value for class 3 semi-compact web

$$\beta_{3w} = 120 \times \varepsilon = 105.617$$

Effective plastic modulus - cl.3.5.6.2

$$S_{\text{eff}} = \min(Z_{xx} + (S_{xx} - Z_{xx}) \times \min(\frac{((\beta_{3w} / (d / t))^2 - 1)}{((\beta_{3w} / \beta_{2w})^2 - 1)}, \frac{((\beta_{3f} / (b / T) - 1) / (\beta_{3f} / \beta_{2f} - 1))}{1}), S_{xx}) = 170473 \text{ mm}^3$$

Moment capacity low shear - cl.4.2.5.2

$$M_c = \min(p_y \times S_{\text{eff}}, 1.2 \times p_y \times Z_{xx}) = 60.5 \text{ kNm}$$

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling

$$L_E = 1.0 \times L_{s1} + 2 \times D = 3055 \text{ mm}$$

Slenderness ratio

$$\lambda = L_E / r_{yy} = 82.609$$

Equivalent slenderness - Section 4.3.6.7

Buckling parameter

$$u = 0.840$$

Torsional index

$$x = 20.701$$

Slenderness factor

$$v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25} = 0.864$$

Ratio - cl.4.3.6.9

$$\beta_W = S_{\text{eff}} / S_{xx} = 0.937$$

Equivalent slenderness - cl.4.3.6.7

$$\lambda_{LT} = u \times v \times \lambda \times \sqrt{\beta_W} = 57.983$$

Limiting slenderness - Annex B.2.2

$$\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5} = 30.198$$

$\lambda_{LT} > \lambda_{L0}$ - Allowance should be made for lateral-torsional buckling

Bending strength - Section 4.3.6.5

Robertson constant

$$\alpha_{LT} = 7.0$$

Perry factor

$$\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) = 0.194$$

Euler stress

$$p_E = \pi^2 \times E / \lambda_{LT}^2 = 601.8 \text{ N/mm}^2$$

$$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 = 536.9 \text{ N/mm}^2$$

Bending strength - Annex B.2.1

$$p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) = 263.7 \text{ N/mm}^2$$

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment

$$M_2 = 27.7 \text{ kNm}$$

Moment at centre-line of segment

$$M_3 = 36.9 \text{ kNm}$$

Moment at three quarter point of segment

$$M_4 = 27.7 \text{ kNm}$$

Maximum moment in segment

$$M_{\text{abs}} = 36.9 \text{ kNm}$$

Maximum moment governing buckling resistance

$$M_{LT} = M_{\text{abs}} = 36.9 \text{ kNm}$$

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM C				Start page no./Revision 4	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Equivalent uniform moment factor for lateral-torsional buckling

$$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44) = \mathbf{0.925}$$

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment

$$M_b = p_b \times S_{eff} = \mathbf{45 \text{ kNm}}$$

$$M_b / m_{LT} = \mathbf{48.6 \text{ kNm}}$$

PASS - Buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to imposed loads

Limiting deflection

$$\delta_{lim} = L_{s1} / 360 = \mathbf{7.639 \text{ mm}}$$

Maximum deflection span 1

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{1.308 \text{ mm}}$$

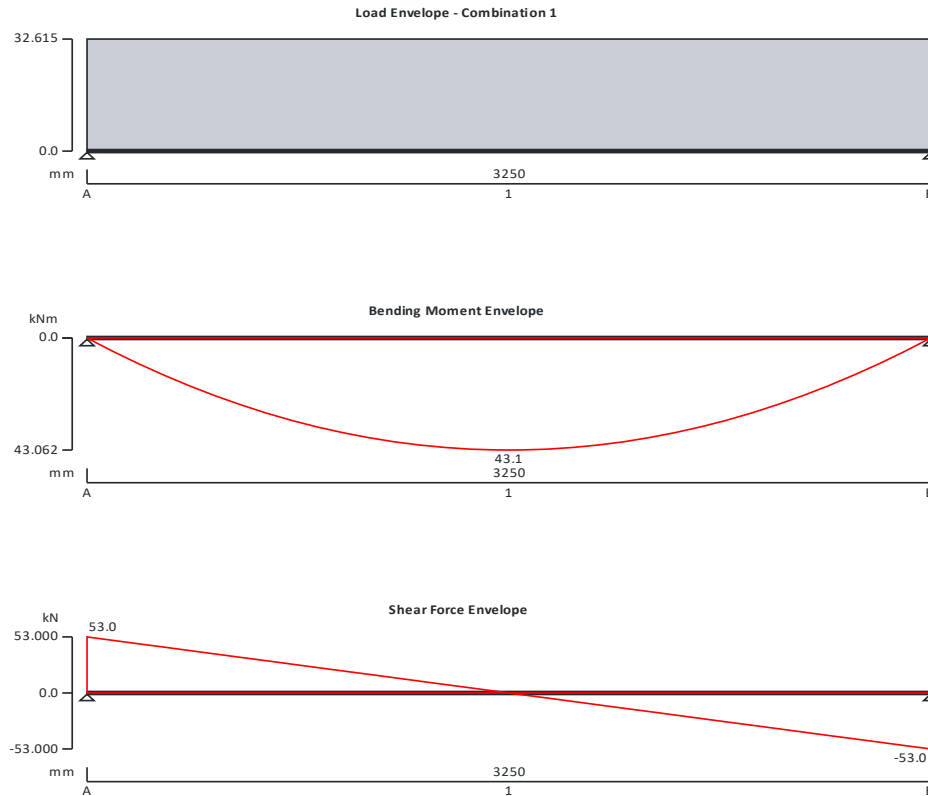
PASS - Maximum deflection does not exceed deflection limit

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM D				Start page no./Revision 1	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

STEEL BEAM ANALYSIS & DESIGN (BS5950)

In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.07



Support conditions

Support A

Vertically restrained

Rotationally free

Support B

Vertically restrained

Rotationally free

Applied loading

Beam loads

Dead self weight of beam $\times 1$

roof - Dead full UDL 8 kN/m

roof - Imposed full UDL 4 kN/m

wall - Dead full UDL 10.5 kN/m

Load combinations

Load combination 1

Support A

Dead $\times 1.40$

Imposed $\times 1.60$

Dead $\times 1.40$

Imposed $\times 1.60$

Support B

Dead $\times 1.40$

Imposed $\times 1.60$

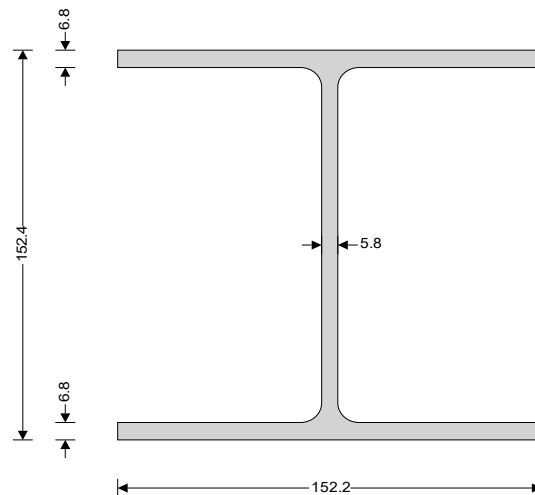
Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM D				Start page no./Revision 2	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Analysis results

Maximum moment	$M_{max} = 43.1 \text{ kNm}$	$M_{min} = 0 \text{ kNm}$
Maximum shear	$V_{max} = 53 \text{ kN}$	$V_{min} = -53 \text{ kN}$
Deflection	$\delta_{max} = 2.3 \text{ mm}$	$\delta_{min} = 0 \text{ mm}$
Maximum reaction at support A	$R_{A_max} = 53 \text{ kN}$	$R_{A_min} = 53 \text{ kN}$
Unfactored dead load reaction at support A	$R_{A_Dead} = 30.4 \text{ kN}$	
Unfactored imposed load reaction at support A	$R_{A_Imposed} = 6.5 \text{ kN}$	
Maximum reaction at support B	$R_{B_max} = 53 \text{ kN}$	$R_{B_min} = 53 \text{ kN}$
Unfactored dead load reaction at support B	$R_{B_Dead} = 30.4 \text{ kN}$	
Unfactored imposed load reaction at support B	$R_{B_Imposed} = 6.5 \text{ kN}$	

Section details

Section type	UC 152x152x23 (British Steel Section Range 2022 (BS4-1))
Steel grade	S355
From table 9: Design strength p_y	
Thickness of element	$\max(T, t) = 6.8 \text{ mm}$
Design strength	$p_y = 355 \text{ N/mm}^2$
Modulus of elasticity	$E = 205000 \text{ N/mm}^2$



Lateral restraint

Span 1 has lateral restraint at supports only

Effective length factors

Effective length factor in major axis	$K_x = 1.00$
Effective length factor in minor axis	$K_y = 1.00$
Effective length factor for lateral-torsional buckling	$K_{LTA} = 1.00 + 2 \times D$
	$K_{LTB} = 1.00 + 2 \times D$

Classification of cross sections - Section 3.5

$$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]} = 0.88$$

Internal compression parts - Table 11

Depth of section	$d = 123.6 \text{ mm}$	
	$d / t = 24.2 \times \varepsilon \leq 80 \times \varepsilon$	Class 1 plastic

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM D				Start page no./Revision 3	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Outstand flanges - Table 11

Width of section

$$b = B / 2 = 76.1 \text{ mm}$$

$$b / T = 12.7 \times \varepsilon \leq 15 \times \varepsilon$$

Class 3 semi-compact

Section is class 3 semi-compact

Shear capacity - Section 4.2.3

Design shear force

$$F_v = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 53 \text{ kN}$$

$$d / t < 70 \times \varepsilon$$

Web does not need to be checked for shear buckling

Shear area

$$A_v = t \times D = 884 \text{ mm}^2$$

Design shear resistance

$$P_v = 0.6 \times p_y \times A_v = 188.3 \text{ kN}$$

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment

$$M = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = 43.1 \text{ kNm}$$

Effective plastic modulus - Section 3.5.6

Limiting value for class 2 compact flange

$$\beta_{2f} = 10 \times \varepsilon = 8.801$$

Limiting value for class 3 semi-compact flange

$$\beta_{3f} = 15 \times \varepsilon = 13.202$$

Limiting value for class 2 compact web

$$\beta_{2w} = 100 \times \varepsilon = 88.014$$

Limiting value for class 3 semi-compact web

$$\beta_{3w} = 120 \times \varepsilon = 105.617$$

Effective plastic modulus - cl.3.5.6.2

$$S_{\text{eff}} = \min(Z_{xx} + (S_{xx} - Z_{xx}) \times \min(\frac{((\beta_{3w} / (d / t))^2 - 1)}{((\beta_{3w} / \beta_{2w})^2 - 1)}, \frac{((\beta_{3f} / (b / T) - 1)}{(\beta_{3f} / \beta_{2f} - 1)})), S_{xx}) = 170473 \text{ mm}^3$$

Moment capacity low shear - cl.4.2.5.2

$$M_c = \min(p_y \times S_{\text{eff}}, 1.2 \times p_y \times Z_{xx}) = 60.5 \text{ kNm}$$

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling

$$L_E = 1.0 \times L_{s1} + 2 \times D = 3555 \text{ mm}$$

Slenderness ratio

$$\lambda = L_E / r_{yy} = 96.130$$

Equivalent slenderness - Section 4.3.6.7

Buckling parameter

$$u = 0.840$$

Torsional index

$$x = 20.701$$

Slenderness factor

$$v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25} = 0.833$$

Ratio - cl.4.3.6.9

$$\beta_W = S_{\text{eff}} / S_{xx} = 0.937$$

Equivalent slenderness - cl.4.3.6.7

$$\lambda_{LT} = u \times v \times \lambda \times \sqrt{\beta_W} = 65.058$$

Limiting slenderness - Annex B.2.2

$$\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5} = 30.198$$

$\lambda_{LT} > \lambda_{L0}$ - Allowance should be made for lateral-torsional buckling

Bending strength - Section 4.3.6.5

Robertson constant

$$\alpha_{LT} = 7.0$$

Perry factor

$$\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) = 0.244$$

Euler stress

$$p_E = \pi^2 \times E / \lambda_{LT}^2 = 478 \text{ N/mm}^2$$

$$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 = 474.8 \text{ N/mm}^2$$

Bending strength - Annex B.2.1

$$p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) = 238.7 \text{ N/mm}^2$$

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment

$$M_2 = 32.3 \text{ kNm}$$

Moment at centre-line of segment

$$M_3 = 43.1 \text{ kNm}$$

Moment at three quarter point of segment

$$M_4 = 32.3 \text{ kNm}$$

Maximum moment in segment

$$M_{\text{abs}} = 43.1 \text{ kNm}$$

Maximum moment governing buckling resistance

$$M_{LT} = M_{\text{abs}} = 43.1 \text{ kNm}$$

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for STEEL BEAM D				Start page no./Revision 4	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Equivalent uniform moment factor for lateral-torsional buckling

$$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44) = \mathbf{0.925}$$

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment

$$M_b = p_b \times S_{eff} = \mathbf{40.7 \text{ kNm}}$$

$$M_b / m_{LT} = \mathbf{44 \text{ kNm}}$$

PASS - Buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to imposed loads

Limiting deflection

$$\delta_{lim} = L_{s1} / 360 = \mathbf{9.028 \text{ mm}}$$

Maximum deflection span 1

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{2.268 \text{ mm}}$$

PASS - Maximum deflection does not exceed deflection limit

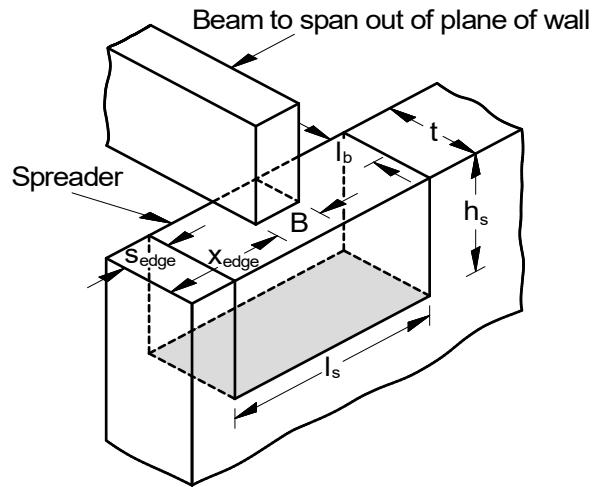
Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for MASONRY BEARING PERPENDICULAR				Start page no./Revision 1	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

MASONRY BEARING DESIGN TO BS5628-1:2005

TEDDS calculation version 1.0.08

Masonry details

Masonry type	Aggregate concrete blocks (25% or less formed voids)
Compressive strength of unit	$p_{unit} = 20.0 \text{ N/mm}^2$
Mortar designation	iii
Least horizontal dimension of masonry units	$l_{unit} = 100 \text{ mm}$
Height of masonry units	$h_{unit} = 215 \text{ mm}$
Category of masonry units	Category II
Category of construction control	Normal
Partial safety factor for material strength	$\gamma_m = 3.5$
Thickness of load bearing leaf	$t = 100 \text{ mm}$
Effective thickness of masonry wall	$t_{ef} = 133 \text{ mm}$
Height of masonry wall	$h = 2400 \text{ mm}$
Effective height of masonry wall	$h_{ef} = 2400 \text{ mm}$



Bearing details

Beam spanning out of plane of wall	
Width of bearing	$B = 100 \text{ mm}$
Length of bearing	$l_b = 100 \text{ mm}$
Edge distance	$X_{edge} = 500 \text{ mm}$
Compressive strength from Table 2 BS5628:Part 1 - aggregate concrete blocks (25% or less formed voids)	
Mortar designation	Mortar = "iii"
Block compressive strength	$p_{unit} = 20.0 \text{ N/mm}^2$
Characteristic compressive strength (Table 2c)	$f_{kc} = 5.55 \text{ N/mm}^2$
Characteristic compressive strength (Table 2d)	$f_{kd} = 11.05 \text{ N/mm}^2$
Height of solid block	$h_{unit} = 215.0 \text{ mm}$
Least horizontal dimension	$l_{unit} = 100.0 \text{ mm}$

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for MASONRY BEARING PERPENDICULAR				Start page no./Revision 2	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Block ratio	ratio = $h_{unit} / l_{unit} = 2.2$	Ratio between 0.6 and 4.5 - OK
Characteristic compressive strength	$f_k = 11.05 \text{ N/mm}^2$	
Loading details		
Characteristic concentrated dead load	$G_k = 50 \text{ kN}$	
Characteristic concentrated imposed load	$Q_k = 35 \text{ kN}$	
Design concentrated load	$F = (G_k \times 1.4) + (Q_k \times 1.6) = 126.0 \text{ kN}$	
Characteristic distributed dead load	$g_k = 0.0 \text{ kN/m}$	
Characteristic distributed imposed load	$q_k = 0.0 \text{ kN/m}$	
Design distributed load	$f = (g_k \times 1.4) + (q_k \times 1.6) = 0.0 \text{ kN/m}$	
Masonry bearing type		
Bearing type	Type 2	
Bearing safety factor	$\gamma_{bear} = 1.50$	
Check design bearing without a spreader		
Design bearing stress	$f_{ca} = F / (B \times l_b) + f / t = 12.600 \text{ N/mm}^2$	
Allowable bearing stress	$f_{cp} = \gamma_{bear} \times f_k / \gamma_m = 4.736 \text{ N/mm}^2$	
FAIL - Design bearing stress exceeds allowable bearing stress, use a spreader		
Spreader details		
Length of spreader	$l_s = 400 \text{ mm}$	
Depth of spreader	$h_s = 215 \text{ mm}$	
Edge distance	$s_{edge} = \max(0 \text{ mm}, x_{edge} - (l_s - B) / 2) = 350 \text{ mm}$	
Spreader bearing type		
Bearing type	Type 2	
Bearing safety factor	$\gamma_{bear} = 1.50$	
Check design bearing with a spreader		
Loading acts at midpoint of spreader		
Design bearing stress	$f_{ca} = F / (l_s \times t) + f / t = 3.150 \text{ N/mm}^2$	
Allowable bearing stress	$f_{cp} = \gamma_{bear} \times f_k / \gamma_m = 4.736 \text{ N/mm}^2$	
PASS - Allowable bearing stress exceeds design bearing stress		
Check design bearing at $0.4 \times h$ below the bearing level		
Slenderness ratio	$h_{ef} / t_{ef} = 18.05$	
Eccentricity at top of wall	$e_x = 16.7 \text{ mm}$	
From BS5628:1 Table 7		
Capacity reduction factor	$\beta = 0.61$	
Length of bearing distributed at $0.4 \times h$	$l_d = 1560 \text{ mm}$	
Maximum bearing stress	$f_{ca} = F / (l_d \times t) + f / t = 0.808 \text{ N/mm}^2$	
Allowable bearing stress	$f_{cp} = \beta \times f_k / \gamma_m = 1.940 \text{ N/mm}^2$	
PASS - Allowable bearing stress at $0.4 \times h$ below bearing level exceeds design bearing stress		

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for MASONRY BEARING PARALLEL				Start page no./Revision 1	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

MASONRY BEARING DESIGN TO BS5628-1:2005

TEDDS calculation version 1.0.08

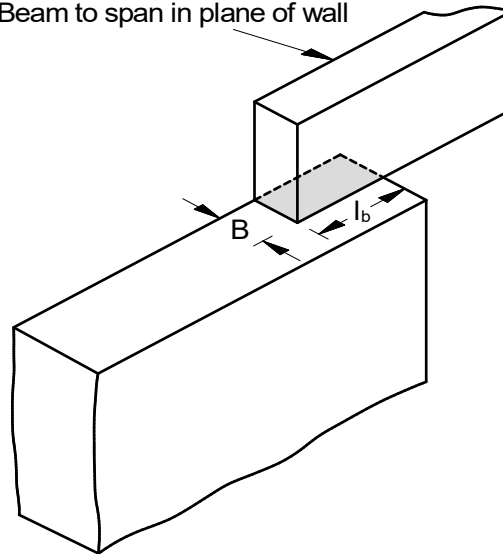
Masonry details

Masonry type
Compressive strength of unit
Mortar designation
Least horizontal dimension of masonry units
Height of masonry units
Category of masonry units
Category of construction control
Partial safety factor for material strength
Thickness of load bearing leaf
Effective thickness of masonry wall
Height of masonry wall
Effective height of masonry wall

Aggregate concrete blocks (25% or less formed voids)

$p_{unit} = 20.0 \text{ N/mm}^2$
iii
 $l_{unit} = 100 \text{ mm}$
 $h_{unit} = 215 \text{ mm}$
Category II
Normal
 $\gamma_m = 3.5$
 $t = 100 \text{ mm}$
 $t_{ef} = 133 \text{ mm}$
 $h = 2400 \text{ mm}$
 $h_{ef} = 2400 \text{ mm}$

Beam to span in plane of wall



Bearing details

Beam spanning in plane of wall
Width of bearing
Length of bearing

$B = 100 \text{ mm}$
 $l_b = 200 \text{ mm}$

Compressive strength from Table 2 BS5628:Part 1 - aggregate concrete blocks (25% or less formed voids)

Mortar designation
Block compressive strength
Characteristic compressive strength (Table 2c)
Characteristic compressive strength (Table 2d)
Height of solid block
Least horizontal dimension
Block ratio

Mortar = "iii"
 $p_{unit} = 20.0 \text{ N/mm}^2$
 $f_{kc} = 5.55 \text{ N/mm}^2$
 $f_{kd} = 11.05 \text{ N/mm}^2$
 $h_{unit} = 215.0 \text{ mm}$
 $l_{unit} = 100.0 \text{ mm}$
ratio = $h_{unit} / l_{unit} = 2.2$

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for MASONRY BEARING PARALLEL				Start page no./Revision 2	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Ratio between 0.6 and 4.5 - OK

Characteristic compressive strength

$$f_k = 11.05 \text{ N/mm}^2$$

Loading details

Characteristic concentrated dead load

$$G_k = 50 \text{ kN}$$

Characteristic concentrated imposed load

$$Q_k = 15 \text{ kN}$$

Design concentrated load

$$F = (G_k \times 1.4) + (Q_k \times 1.6) = 94.0 \text{ kN}$$

Characteristic distributed dead load

$$g_k = 0.0 \text{ kN/m}$$

Characteristic distributed imposed load

$$q_k = 0.0 \text{ kN/m}$$

Design distributed load

$$f = (g_k \times 1.4) + (q_k \times 1.6) = 0.0 \text{ kN/m}$$

Masonry bearing type

Bearing type

Type 2

Bearing safety factor

$$\gamma_{\text{bear}} = 1.50$$

Check design bearing without a spreader

Design bearing stress

$$f_{ca} = F / (B \times l_b) + f / t = 4.700 \text{ N/mm}^2$$

Allowable bearing stress

$$f_{cp} = \gamma_{\text{bear}} \times f_k / \gamma_m = 4.736 \text{ N/mm}^2$$

PASS - Allowable bearing stress exceeds design bearing stress

Check design bearing at $0.4 \times h$ below the bearing level

Slenderness ratio

$$h_{\text{ef}} / t_{\text{ef}} = 18.05$$

Eccentricity at top of wall

$$e_x = 0.0 \text{ mm}$$

From BS5628:1 Table 7

Capacity reduction factor

$$\beta = 0.83$$

Length of bearing distributed at $0.4 \times h$

$$l_d = 1160 \text{ mm}$$

Maximum bearing stress

$$f_{ca} = F / (l_d \times t) + f / t = 0.810 \text{ N/mm}^2$$

Allowable bearing stress

$$f_{cp} = \beta \times f_k / \gamma_m = 2.635 \text{ N/mm}^2$$

PASS - Allowable bearing stress at $0.4 \times h$ below bearing level exceeds design bearing stress

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for 1st FLOOR TIMBER JOISTS				Start page no./Revision 1	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

TIMBER JOIST DESIGN (BS5268-2:2002)

Tedds calculation version 1.1.04

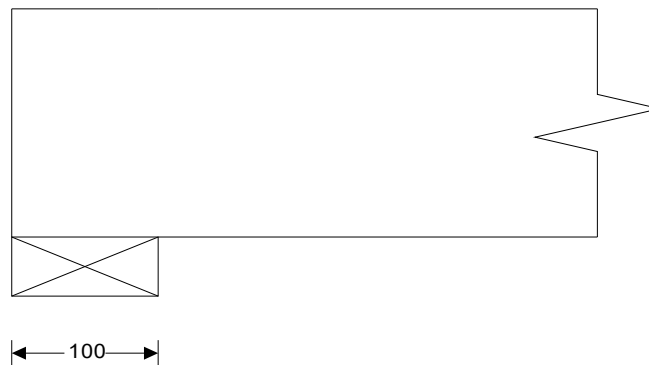
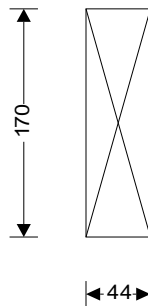
Joist details

Joist breadth	b = 44 mm
Joist depth	h = 170 mm
Joist spacing	s = 450 mm
Timber strength class	C16
Service class of timber	1



Span details

Number of spans	N _{span} = 1
Length of bearing	L _b = 100 mm
Effective length of span	L _{s1} = 2750 mm



Section properties

Second moment of area	I = b × h ³ / 12 = 18014333 mm ⁴
Section modulus	Z = b × h ² / 6 = 211933 mm ³

Loading details

Joist self weight	F _{swt} = b × h × p _{char} × g _{acc} = 0.02 kN/m
Dead load	F _{d_udi} = 0.75 kN/m ²
Imposed UDL(Long term)	F _{i_udi} = 1.50 kN/m ²
Imposed point load (Medium term)	F _{i_pt} = 1.40 kN

Modification factors

Service class for bending parallel to grain	K _{2m} = 1.00
Service class for compression	K _{2c} = 1.00
Service class for shear parallel to grain	K _{2s} = 1.00
Service class for modulus of elasticity	K _{2e} = 1.00

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for 1st FLOOR TIMBER JOISTS				Start page no./Revision 2	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

Section depth factor $K_7 = 1.06$
Load sharing factor $K_8 = 1.10$

Consider long term loads

Load duration factor $K_3 = 1.00$
Maximum bending moment $M = 0.979$ kNm
Maximum shear force $V = 1.423$ kN
Maximum support reaction $R = 1.423$ kN
Maximum deflection $\delta = 5.149$ mm

Check bending stress

Bending stress $\sigma_m = 5.300$ N/mm²
Permissible bending stress $\sigma_{m_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8 = 6.206$ N/mm²
Applied bending stress $\sigma_{m_max} = M / Z = 4.618$ N/mm²
PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress $\tau = 0.670$ N/mm²
Permissible shear stress $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8 = 0.737$ N/mm²
Applied shear stress $\tau_{max} = 3 \times V / (2 \times b \times h) = 0.285$ N/mm²
PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane) $\sigma_{cp1} = 2.200$ N/mm²
Permissible bearing stress $\sigma_{c_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8 = 2.420$ N/mm²
Applied bearing stress $\sigma_{c_max} = R / (b \times L_b) = 0.324$ N/mm²
PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection $\delta_{adm} = \min(L_{s1} \times 0.003, 14 \text{ mm}) = 8.250$ mm
Bending deflection (based on E_{mean}) $\delta_{bending} = 4.863$ mm
Shear deflection $\delta_{shear} = 0.285$ mm
Total deflection $\delta = \delta_{bending} + \delta_{shear} = 5.149$ mm
PASS - Actual deflection within permissible limits

Consider medium term loads

Load duration factor $K_3 = 1.25$
Maximum bending moment $M = 1.303$ kNm
Maximum shear force $V = 1.895$ kN
Maximum support reaction $R = 1.895$ kN
Maximum deflection $\delta = 5.899$ mm

Check bending stress

Bending stress $\sigma_m = 5.300$ N/mm²
Permissible bending stress $\sigma_{m_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8 = 7.757$ N/mm²
Applied bending stress $\sigma_{m_max} = M / Z = 6.148$ N/mm²
PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress $\tau = 0.670$ N/mm²
Permissible shear stress $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8 = 0.921$ N/mm²
Applied shear stress $\tau_{max} = 3 \times V / (2 \times b \times h) = 0.380$ N/mm²

Project 10 LLOYD ROAD, PRESCOT, KNOWSLEY (L34 6LG)				Job no. 2555	
Calcs for 1st FLOOR TIMBER JOISTS				Start page no./Revision 3	
Calcs by JS	Calcs date 28/03/2023	Checked by SR	Checked date 28/03/2023	Approved by	Approved date

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane)

$$\sigma_{cp1} = 2.200 \text{ N/mm}^2$$

Permissible bearing stress

$$\sigma_{c_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8 = 3.025 \text{ N/mm}^2$$

Applied bearing stress

$$\sigma_{c_max} = R / (b \times L_b) = 0.431 \text{ N/mm}^2$$

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection

$$\delta_{adm} = \min(L_{s1} \times 0.003, 14 \text{ mm}) = 8.250 \text{ mm}$$

Bending deflection (based on E_{mean})

$$\delta_{bending} = 5.519 \text{ mm}$$

Shear deflection

$$\delta_{shear} = 0.380 \text{ mm}$$

Total deflection

$$\delta = \delta_{bending} + \delta_{shear} = 5.899 \text{ mm}$$

PASS - Actual deflection within permissible limits